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Relative Clause Attachment Ambiguity Resolution in L1-Persian Learners of L2 English: The Effects of Semantic Priming and Proficiency

Mohammad Nabi Karimi[1*], Eskandar Samadi [2], Esmat Babaii[3]

[1*]Professor of Applied Linguistics, Department of Foreign Languages, Kharazmi University, Tehran, Iran, *Karimi_mn@khu.ac.ir*

[2]Ph.D. Candidate in Applied Linguistics, Department of Foreign Languages, Kharazmi University, Tehran, Iran, *Std_samadi@khu.ac.ir*

[3]Professor of Applied Linguistics, Department of Foreign Languages, Kharazmi University, Tehran, Iran, *babaii@khu.ac.ir*

Abstract

The present study explored the effect of semantic priming in the resolution of ambiguous sentences containing Relative Clauses (RCs) preceded by a complex Noun Phrase (NP) by L1-Persian learners of L2 English. The type of semantic relationship examined was the one between the RC and one of the NPs in the complex NP to find out whether semantic manipulation through priming one of the NPs to the RC can affect L2 learners' attachment preference. The participants were 60 L1-Persian learners of L2 English with different proficiency levels. In a self-paced Paraphrase Decision Task using E-prime software, their reading times and attachment preferences while reading ambiguous sentences were examined. The low-proficiency participants' off-line (RC attachment preferences) and on-line data (reading times) were compared with off-line and on-line data obtained from high-proficiency participants. The results revealed that in both groups, semantic priming affected participants' attachment preferences. These findings are consistent with Constraint-based Models of sentence processing, which assume that several sources of information, including semantics, are used in sentence processing. The results also support predictions of the Spreading Activation Model. There were also significant differences between the two groups, low-proficiency participants fully transferred their L1 (Persian) processing strategies to their L2 (English). However, high-proficiency participants processed sentences similarly to native English speakers even though there were still traces of their L1 parsing preferences which is consistent with Shallow Structure Hypothesis.

Keywords: Ambiguity Resolution, L2 Learners, Proficiency, RC Attachment, Semantic Priming

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1. Introduction

In the psycholinguistic literature, ambiguous relative clause (RC) is one of the most broadly studied syntactic structures. In this type of ambiguity, the RC is preceded by two noun phrases (NPs), and these two NPs are linked by the genitive *of* and the RC can be attached to either of these NPs. As in the following example:

(1) *Alex saw [the servant]$_{NP1}$ of [the actor]$_{NP2}$ [who was drinking coffee]$_{RC}$.*

This sentence is ambiguous regarding the attachment of the RC. In this example, the RC *who was drinking coffee* can refer to either *the servant* or *the actor*. When the RC is attached to NP1, it results in a high attachment (NP1), meaning that "*the servant was drinking coffee*", and when the RC is attached to NP2, it leads to a low attachment (NP2), which means that "*the actor was drinking coffee*".

Numerous studies have been conducted to investigate RC attachment preferences in different languages (e.g., Dussias & Sagarra, 2007; Felser et al., 2003; Fernandez, 2003; Hemforth et al., Walter, 2015; Jegerski et al., 2016; Kim & Christianson, 2013; Papadopoulou & Clahsen, 2003) each focusing on a specific factor, and the way it influences attachment preferences. Research investigating this type of structural ambiguity has concluded that there exist cross-linguistic differences in RC attachment preferences. On the one hand, previous psycholinguistic studies have shown that in these types of sentences, adult native speakers of English have a tendency to attach the ambiguous RC to NP2 (Bergmann et al., 2008; Dekydtspotter et al., 2008; Grillo & Costa, 2014; Hemforth, et al., 2015). Besides English, NP2 attachment preference has been reported in Brazilian (Finger & Zimmer, 2000), Japanese (Jun & Koike, 2008), Swedish, Romanian, and Norwegian languages (Ehrlich et al., 1999).

On the other hand, high attachment (NP1) preferences have been reported in sentences equal to (1) in languages including Arabic (Bidaoui, & Abunasser, 2016), Dutch (Desmet et al., 2006), French (Dekydtspotter et al., 2008), German (Hemforth et al., 2015), Greek (Papadopoulou & Clahsen, 2003), Persian (Arabmofrad & Marefat, 2008; Shabani, 2016), Russian (Iudina & Fedorova, 2009) and Spanish (Dussias & Sagarra, 2007; Fernandez, 2003).

Of course, besides cross-linguistic differences, other factors have also been shown to play a role in participants' RC attachment preferences. Earlier research has revealed that RC attachment preferences are controlled by many different factors such as animacy (Desmet & Declercq, 2006), participants' age (Ha, 2005), types of task (Miyao & Omaki, 2006), length of RC

(Fernandez, 2003), position of RC (Hemforth et al., 2015), L1 Transfer (Fernandez, 1999), the amount of exposure (Caffarra et al., 2015; Dekeyser, 2005; Dussias & Sagarra, 2007), proficiency level (Miyao & Omaki, 2006), prosody (Dekydtspotter et al., 2008; Fodor, 2002; Zahn & Scheepers, 2015), alternative structures availability (Mitchell et al., 2000), the type of relativizing component (Hemforth, et al., 2000), individual differences in working memory capacity (Kim & Christianson, 2013; Marefat & Farzizadeh, 2018; Marefat & Samadi, 2015; Swets et al., 2007; Traxler, 2007), relative pronoun type (Delle Luche et al., 2006), as well as the effects of semantics on RC attachment preferences (Marefat & Samadi, 2015). However, there is a gap considering the semantic relationship between specific elements in a sentence. Recent studies on sentence processing revealed that there are situations in which the strong semantic relationships between words in a sentence, "can block the semantic interpretation that is actually prescribed by the syntactic structure of that sentence" (Hoeks et al., 2003, p. 175). However, previous studies have not explored whether the semantic relationship between the RC and one of the NPs in a complex NP would affect attachment preferences of L2ers with different levels of proficiency to find out whether participants with higher levels of proficiency process these types of sentences differently from those with lower levels of proficiency. This study sets out to examine whether semantics affects L2ers' parsing preferences and whether low-proficiency participants process these sentences differently compared with high-proficiency participants. The results would help clarify whether L2ers transfer their L1 parsing preferences or they process these sentences similarly to native English speakers.

2. Literature Review

2.1 Parsing Models in L2 learners

Considering the processing of temporarily ambiguous structures, there has been a long-established discussion with regard to what sorts of information are used by parsers during processing of ambiguous sentences (e.g., Clifton 2000; Pickering et al. 2000; Van Gompel & Pickering 2007; Traxler et al. 2000). According to Harley (2013), two competing and incompatible accounts dominate current sentence processing studies in psycholinguistics. One is known as the Autonomous model and the other is referred to as the Interactive model. These two models are also known as One-stage and Two-stage models, respectively. Based on Autonomous models, such as the Garden Path Model, only syntactic information is used in the initial stages of parsing to construct a syntactic representation. In these models, syntactic processing is autonomous and done prior to the processing semantic information (Frazier, 1987; Frazier & Fodor, 1978; Friederici,

2002). According to these models, the language processor computes syntactic analyses serially, in two separate stages. In the initial stage, the processor makes use of a limited range of information resources in order to construct the initial analysis. In the second stage, the processor has access to other sources of information, which may make it drop out the initial analysis and compute alternative analyses. Based on Interactive models, also known as Constraint-based Models (MacDonald, 1994; MacDonald et al., 1994; Taraban & Mc Clelland, 1988), all types of information are used to select among alternative structures. In addition to syntactic information, the processor makes use of several sources of information, including syntactic, discourse, and semantic information which are called constraints to construct a syntactic representation at an early stage of parsing (Frazier, & Fodor, 1978; Grainger et al., 2010; Mc-Rae et al., 1998; Tabor & Hutchins, 2004; Trueswell, 1996; Vosse & Kempen, 2000). In the following similarities and differences in RC attachment preferences in L1 and L2 are presented.

2.2 Differences in Processing in L1 and L2

Expanding L1 research on RC attachment, studies on RC attachment in L2 have tried to explain the similarities and differences between L1 and L2 processing strategies. A number of authors argue that syntactic parsing is different in L1 and L2 (Clahsen & Felser, 2006; Felser et al. 2003; Marinis et al., 2005; Papadopoulu & Clahsen, 2003; Ullman, 2006).

According to the Shallow Structure Hypothesis, parsing is different across L1 and L2 because the syntactic representations constructed by L2ers "are shallower and less detailed than those of native speakers" (Clahsen & Felser, 2006, p. 32). Other authors (e.g., Caplan & Waters, 2013, Dekydtspotter & Renaud, 2014; Hopp, 2014; Kim & Christianson, 2017; Witzel et al., 2012), have proposed that cognitive resources such as working memory capacity (WMC) and L2 proficiency lead to differences in L2 sentence processing, making these variables significantly more demanding in L2 compared to L1.

Considering Persian and English, the syntactic relationship of NP1 and NP2 in both languages are the same. That is, in English high attachment NP1 is joined to low attachment NP2 via genitive "of" which is a morphemic marker while its counterpart in Persian, i.e., NP1 and NP2 are attached together via Ezafeh- construction "Kasre" which is phonemically instantiated. Concerning the semantic role, in both languages NP1 is possessor while NP2 is possessed.

2.3. Attachment Preferences in L2 Learners

Many studies have investigated attachment preferences by L2 learners (Felser et al. 2003; Marefat & Farzizadeh, 2018; Marefat & Samadi, 2015;

Papadopoulou & Clahsen, 2003). Clahsen and Felser (2006) posit that in the context of L2 sentence processing, "the syntactic representations adult L2 learners compute for comprehension are shallower and less detailed than those of native speakers" (p. 32). They indicated that, according to proposals on the basis of research with native speakers (e.g., Ferreira et al., 2002), during sentence processing, the human processing system allows for two entirely different ways of computing sentence representations known as full parsing and shallow parsing. Full parsing encompasses the construction of a fully specified syntactic representation while shallow parsing is based on pragmatic and lexical information.

According to Clahsen and Felser (2006), late learners cannot use the same structurally-based processing principles that native speakers use, since their L2 sentence comprehension representations are not as elaborate as those of native speakers. For this reason, high-proficiency participants have not processed the sentences, similar to native speakers in their study.

Fernandez (1999), in an off-line study, examined relative clause attachment preferences in English. The participants were two groups of early and late Spanish learners of L2 English and English adult native speakers. The experimental sentences consisted of ambiguous sentences containing ambiguous RCs preceded by a complex NP in which two NPs were linked together by the genitive *of*. A clear low-attachment preference was observed among the native speakers. However, both groups of L2 learners had more high-attachment preferences compared to native speakers. Fernandez stated that this happened as a result of participants' L1 transfer.

Besides, Felser et al. (2003) examined two groups of highly-proficient Greek and German learners of English. They used two different tasks, a questionnaire and a self-paced reading task. The results showed that both Greek and German learners preferred a low attachment in sentences containing lexical PP antecedents (i.e., NP1-*with*-NP2), such as "*The dean observed the professor with the researcher who was never happy"*. However, in equivalent sentences with genitive *of* antecedents (i.e., NP1-*of*-NP2) antecedents such as "*The dean observed the professor of the researcher who was never happy"*, L2 learners did not have any clear attachment preference.

In another study, Papadopoulou and Clahsen (2003) examined RC attachment preferences in native speakers of Greek, and three groups of L2 learners of Greek with different L1s. They found that with PP antecedents, similar to Greek native speakers, advanced L2 learners of Greek with Russian, German or Spanish as their L1s showed low-attachment preferences. However, with genitive antecedents, they did not show any clear attachment preference. The findings reveal that L2 learners process

ambiguous sentences neither similarly to their L1 nor similarly to Greek native speakers. The authors suggested that in parsing ambiguous sentences, L2 learners integrate information in a different way, and tend to rely more "on lexical cues than the native speakers and less on purely structurally-based parsing strategies" (Papadopoulou & Clahsen, 2003, p. 502).

Marefat and Farzizadeh (2018) also examined RC attachment preferences in 62 highly-advanced Persian leaners of English. The participants read sentences with ambiguous RCs in both their L1 (Persian) and L2 (English). The results showed that in both Persian and English Languages, the participants processed the ambiguous sentences similar to native English speakers. They displayed a parsing pattern typical of the target language and a tendency to unlearn their L1 parsing routine. In the following section, the different factors that affect participants' attachment preferences are discussed.

2.4. Factors Affecting RC Attachment Preferences

As mentioned earlier, previous studies investigated different factors influencing RC attachment preferences such as participants' age, prosody, the type of relativizing element used, individual differences in WMC, the effect of position and length of RC, proficiency, type of task, amount of exposure, semantic priming, etc. Some of these factors are elaborated below.

2.4.1. The Length of RC

Fernandez (2003) investigated RC attachment preferences of monolingual and bilingual speakers of English and Spanish. She examined the effect of the length of RC on participants' attachment preferences using an unspeeded paper-and-pencil questionnaire. Test sentences in the experiment either had a short RC (e.g., *the journalist interviewed the coach of the gymnast that was sick*) or a long RC (e.g., *the journalist interviewed the coach of the gymnast that was signing autographs during the competition*). Fernandez found that within long RCs, Spanish monolingual speakers showed overall higher rates of NP1 attachment. The results for Spanish-English bilinguals showed that when the participants were reading these sentences in English, the length of the RC affected their attachment preferences. But the length of RC did not have any effect on Spanish-English bilinguals' attachment preferences when they were reading ambiguous RCs in Spanish. Fernandez theorizes that sensitivity to length arises in the language in which the participants read these sentences more frequently. Because Spanish-English bilinguals encountered these sentences in English more than they do in Spanish, this might have resulted in the absence of the length effect among the participants.

In another study, Hemforth et al., (2015) examined RC attachment preferences in participants from German, Spanish, and English languages using ambiguous RCs with different lengths. The results showed that for long relative clauses, in all three languages, more high attachment (NP1) interpretations were observed compared to short ones. These findings suggest that the difference between participants in implicit prosodic phrasing resulted in their higher rate of NP1 attachment.

2.4.2. Types of Task

In their study, Miyao and Omaki (2006) investigated Japanese native speakers and Korean-Japanese L2 learners to find out whether the type of tasks (i.e., on-line versus off-line tasks), influences participants' RC attachment preferences or not. They found that Japanese native speakers had a high attachment preference in both off-line and on-line tasks. Moreover, they found that L2 learners had a low attachment preference in on-line tasks while they had a high attachment preference in off-line tasks. They argued that L2 learners had low attachment preference in the on-line tasks because these tasks reduced the processing burden on participants' WMC.

In addition, Dinctopal-Deniz (2010) studied RC attachment preferences in native Turkish speakers, native English speakers, and highly-proficient Turkish L2ers of English. The participants filled out off-line questionnaires and participated in on-line self-paced reading tasks. They read sentences in which the ambiguous RCs were followed by both animate and inanimate antecedents. The results of both off-line and on-line tasks showed that both English and Turkish native speakers preferred to attach the ambiguous RC to NP2. However, results for the Turkish L2 learners of English differed significantly in the off-line and on-line tasks. In the off-line task they had a high attachment preference with both animate and inanimate antecedents. However, in the on-line task, in ambiguous sentences with animate antecedents, they preferred to attach the RC high (i.e., NP1), but with inanimate antecedents, they tended to attach it low (i.e., NP2). They concluded that the type of task affects L2 learners' attachment preferences.

2.4.3. Working Memory Capacity (WMC)

Many studies have demonstrated that people with lower levels of WMC process syntactically ambiguous sentences differently from individuals with higher levels of WMC (Kim & Christianson, 2013; Vos, Gunter et al., 2001).

Swets et al., (2007) studied the role of WMC in RC attachment preferences of Belgian and English native speakers. They reported a negative correlation between WMC scores and participants' NP2 attachment

preference. Readers who had limited WMC divided large segments of text into smaller ones (i.e., chunks) and, as a result, they preferred high (i.e., NP1) attachment.

2.4.4 Proficiency Level

Miyao and Omaki (2006) examined RC attachment ambiguity resolution in Korean leaners of L2 Japanese with different proficiency levels (i.e., intermediate to advance) and Japanese native speakers. In their study, they used an off-line sentence interpretation task and an on-line self-paced reading task. Results from the off-line task demonstrated that both Japanese native speakers and Korean L2 learners had a high attachment preference. Results for the on-line self-paced reading task revealed that while Japanese native speakers had an NP1 preference, Korean L2 learners preferred NP2 attachment. They concluded that L2 learners' proficiency level had affected their attachment preferences.

Moreover, Frenck-Mestre (2002) in an eye-tracking study, investigated RC attachment preferences of low-proficient Spanish (high attachment), low-proficient English (low attachment), and highly-proficient English (low attachment) L2 learners of French (high attachment). While Spanish learners preferred high attachment, the low-proficient English learners demonstrated a trend for low attachment. Also, the highly-proficient English L2 learners of French showed a high attachment preference which was similar to French native speakers. This study revealed the existence of L1 transfer to L2 RC attachment ambiguity resolution in Spanish L2 learners of French. Moreover, the results indicated highly-proficient English learners of French had learned French processing strategies. Therefore, it can be concluded that low-proficient participants process ambiguous sentences differently from high-proficiency participants.

2.4.5. L1 Transfer

Based on the available literature, it is not clear whether language learners process an L2 ambiguous RC similarly to L2 native speakers. Several studies reported similarities in the use of parsing strategies across languages. For example, Fernandez (1999) investigated RC attachment in Spanish (high attachment) L2 learners of English (low attachment). The results demonstrated that while processing English ambiguous sentences, Spanish learners still preferred a high attachment, indicating that they transferred their L1 processing to L2.

Besides, Kim (2010) investigated whether Korean (high attachment) L2 learners of English (low attachment) transfer their L1 processing in RC attachment strategies. She conducted an off-line questionnaire experiment, in which a cloze test containing 40 ambiguous sentences were given to 20

native Koreans. The results indicated that the Korean learners of English transferred the high attachment preference while resolving ambiguous sentences containing RCs in English. She concluded that L1-L2 transfer holds.

However, a number of other studies reported that learners with different L1s did not transfer their attachment preferences from L1 to L2. Papadopoulou and Clahsen (2003) investigated German (high attachment), Spanish (high attachment), and Russian (high attachment) advanced L2 learners of Greek (high attachment). The results showed that learners of both German and Spanish L2 learners of Greek did not have any persistent attachment preference for either NP1 or NP2. The participants neither transferred their L1 strategies to L2 nor showed acquisition of target-like strategies.

2.4.6. The Role of Semantics

To date, very few studies have examined the role of semantics in RC ambiguity resolution. Marefat and Samadi (2015), in a post-interpretive study, intended to find out whether the semantic relationship between the verb or subject of the main clause and one of the NPs affects parsing preferences by L1-Persian learners of L2 English. The results showed that semantic priming did not change participants' attachment preferences; instead, the participants' processing seems to be guided solely by syntactic information.

2.5. Impetus for the Present Research

As discussed above, previous studies have examined how cross-linguistic differences and different factors affect RC attachment preferences. This study intends to achieve two significant purposes. The primary purpose of this study is to examine preferences in resolution of English structurally-ambiguous sentences including RCs preceded by two NPs linked together by genitive *of*, meanwhile controlling the semantic biasedness between the RC and either of the NPs in the case of a complex NP among L1-Persian learners of L2-English. Consider the following sentence as an example:

2) *Henry admired [the bodyguard]$_{NP1}$ of [the president]$_{NP2}$ [who was shooting the suspects]$_{RC}$ last night.*

In this sentence, there is a semantic relationship between NP1 and RC which may bias NP1 attachment preferences. In other words, it is more plausible for a *bodyguard* to shoot the suspects rather than for a president, and this semantic relationship may bias NP1 attachment preference. Moreover, this type of relationship can be explained on the basis of the Spreading Activation Model (Collins & Loftus, 1975; Dell, 1986; Traxler et

al., 2000). Snowden (2015) stated that the spreading activation theory of semantic processing integrated the idea of semantic distance, based on which highly related concepts are located closer together than unrelated ones. Therefore, based on this model, when NP1, *"the bodyguard",* in case of sentence (2) is activated, other words which are semantically associated with it (i.e., *shooting the suspects),* also become activated, and these words reinforce the activation of each other. When the parser intends to disambiguate the ambiguous RC "*who was shooting the suspects*", the first NP (i.e., *the bodyguard*) remains more accessible in comparison to NP2 "*the president"*, as a result, the parser is expected to attach the RC to the more accessible NP which is NP1.

Similarly, the semantic relationship between NP2 and RC may bias NP2 attachment preferences.

3) *Henry admired [the bodyguard]$_{NP1}$ of [the president]$_{NP2}$ [who was giving a speech in the UN]$_{RC}$ last night.*

In sentence (3), there is a semantic relationship between NP2 and RC. It is more reasonable for a *president* to give a speech in the UN than for a bodyguard, and this semantic relationship may bias NP2 attachment preference. Again, in this sentence, based on the Spreading Activation Model, NP2 is more accessible compared to NP1, which makes it a more plausible host for the ambiguous RC. Thus, researchers predict that when the RC is semantically biased towards one of the NPs in the complex NP, that NP would become more salient, causing the RC to be attached to it.

The second purpose of this study is to examine whether participants with different proficiency levels have different attachment preferences in the resolution of structurally ambiguous sentences. To date, majority of researches on L2 sentence processing have concentrated on highly-proficient L2 learners (Dussias & Sagarra, 2007; Felser et al., 2003; Marefat & Farzizadeh, 2018; Papadopoulos & Clashen, 2003). However, to provide proper models of how L2 learners process L2 sentences, L2 proficiency is a crucial variable to consider. This study addresses this issue by investigating participants with different levels of proficiency. If they have different attachment preferences, they could be taken as evidence that proficiency level plays a role.

Against the background presented, the present study aims at answering the following question:

> Does the semantic priming between the RC and one of the NPs in a complex NP influence RC attachment preference of L1-Persian learners of L2-English across different proficiency levels?

3. Method

3.1. Participants

The participants of this study were 60 Persian-speaking learners of English (mean age 22.3, range16-38, 26 females). The sampling was purposive in order to have participants with different proficiency levels. The participants were students from language institutes, university students majoring in English Language Teaching, and English teachers from different universities and institutes in Avaj, Takestan, Tehran, Qazvin, and Gorgan cities in Iran. They were not aware of the purpose of the study.

3.2. Materials and Instruments

3.2.1. Language Proficiency Test

The standardized and validated Oxford Quick Placement was administered as a criterion to divide the participants into two levels of high-proficiency and low-proficiency. The test had sixty multiple-choice items including, grammar, vocabulary, language function, and cloze test sections.

3.2.2. The Main Test

3.2.2.1. Test Sentences

The experimental items were all structurally ambiguous sentences. They contain a main clause and an ambiguous RC that could be attached to two preceding antecedents (see Appendix for experimental sentences). Antecedents were complex NPs consisting of two NPs which were linked together by genitive *of*. The structure of complex NP antecedent is [NP1+of+NP2]. In all experimental items, the RC was presented by the relative pronoun *who* and all the sentences had an animate subject. Sentence (1) below is an example of a test sentence:

(4) Alex saw the patient of the nurse who was speaking to the doctor last week.

On the basis of the relationship between the RC and either of the two NPs in a complex NP, test sentences were categorized into three categories: (1) NP1-biased in which the RC and NP1 are semantically related; (2) NP2-biased which represents a relationship between the RC and NP2, and (3) Unbiased which bears no specific relationship between the RC and either of NPs. In the following, an example for each category is provided.

NP1-biased

(5) Alex saw the patient of the nurse who was seriously injured last week.

NP2-biased

(6) Alex saw the patient of the nurse who was filling the syringe last week.

Unbiased

(7) Alex saw the patient of the nurse who was speaking to the doctor last week.

Sentences (5), (6) and (7) are regarded as a set of test sentences. Prior to the main study and in order to identify the qualified test sentences, a norming study was conducted. Twenty sets of sentences were developed and organized into a questionnaire in order to choose those sentences which met the criteria (see below for the criteria). The questionnaire was distributed among 23 participants from the same target population who had not participated in the main study, to decide whether there is a semantic relationship between the RC and either of the NPs set by the researchers. Moreover, seven experts in the field checked the content of the questionnaire. As each set contains three sentences, there were 60 items altogether in the survey. In each item, the RC was written in bold and the two NPs were underlined. Each item was followed by three choices: NP1, NP2, and Both. The test takers were asked to decide which NP was semantically related to the bold RC. An example is provided below:

(8) Alex saw the patient of the nurse **who was seriously inju**red last week.

the patient ☐ the nurse ☐ both ☐

Here are the criteria for choosing test sentences for the main test:

(1) To be qualified as an NP1-biased item, the first choice, (i.e., the patient) had to be selected by 85% of the testees.

2. To be qualified as an NP2-biased item, the second choice, (i.e., the nurse) needed to be selected by 85% of the testees.

3. Finally, to be qualified as an Unbiased item, the third choice, (i.e., both), had to be selected by 85% of the testees.

Fourteen sets that met the criteria were used in the main experiment. In order to use all the fourteen sets, test sentences were presented in two versions named *Version 1* and *Version 2* to trim the test and to prevent the participants from becoming test-wise. Each version included 14 NP-biased sentences (seven NP1 and seven NP2 RC-biased sentences); there was an Unbiased item for each NP-biased item. Accordingly, there were fourteen Unbiased-RC sentences in each version. If the NP1-biased-RC item of a set

was in *Version 1* of the main test, in *Version 2*, it was replaced with NP2-biased-RC item and vice versa. In each set, the Unbiased item was common in both versions.

Test sentences were divided into four fragments, sentence (4) is repeated below in (9) as an example:

(9) Alex saw/ the patient of the nurse/ who was speaking to the doctor/ last week.

1 2 3 4

This fragmentation is motivated by a need to prevent participants from assigning prosodic structure to the sentences presented and to encourage the natural reading of sentences. In these items, as shown in sentence 9, the third fragment (i.e., the RC) was the critical region in which semantics is manipulated. The fourth segment (i.e., the following adverb of time) was the post-critical region to observe possible spillover effects. The length of the experimental sentences and the number of words that appear in the critical region (i.e., region 3) and post-critical region (i.e., region 4) were balanced by dividing them by the number of syllables in each segment. It can be postulated that if subjects prefer NP1 attachment, then their reading times for critical sections in sentences in which the RC is semantically associated with NP2 would be longer compared to sentences in which the RC is semantically associated with NP1. Conversely, if they have NP2 attachment preference, then, their reading times for sentences in which the RC is semantically associated with NP1 would take longer. Each test sentence was followed by a paraphrase that referred to either NP1 or NP2. Both paraphrases were accurate; in the one half of the sentences, the paraphrases were towards NP1, and in the other half, they were paraphrased towards NP2. An example of a test sentence, together with its paraphrase, is presented below:

(10) David met the teacher of the student who was teaching mathematic last night.

The teacher was teaching mathematics last night.

As observed, this sentence is disambiguated towards NP1 (i.e., high attachment). As another example, consider sentence (11) below in which the paraphrased sentence is disambiguated towards NP2 (i.e., low attachment).

(11) Emma liked the waitress of the actor who was playing in the movie in the afternoon.

The actor was playing in the movie in the afternoon.

3.2.2.2. Filler Sentences

Forty-two filler sentences were developed for this study. Fillers had various grammatical structures including unambiguous RCs and were

matched with experimental sentences in length. The fillers were used to fulfill two purposes. First, to prevent the participants' awareness of the purpose of the study and to prevent consistency in test items. Second, they were used to ensure that the participants paid adequate attention to the task content. An example of a filler sentence is provided below:

(12) Last week Jacob bought a computer which he doesn't like now.

3.2.3. Paraphrase Decision Task (PDT)

As pointed out earlier, in order to use all test sentences, they were divided into two versions so, there were two versions of PDT. Each version consisted of 70 sentences including 28 test sentences, and 42 fillers. The task was implemented through Paraphrase Decision Task using E-Prime 2.1 software. In PDT, participants are required to read sentences in a self-paced fashion; after reading the sentence they would be asked to decide whether that paraphrase is correct or not. The stimuli were presented to the participants in a self-paced, chunk-by-chunk, noncumulative fashion. All items, including experimental sentences and fillers were followed by a paraphrase of that sentence. The participants were required to decide whether that paraphrase was correct or not by pressing the 'Right arrow' or the 'Left arrow' respectively. (see Procedure for details). The distribution of the different sentences in each version of the main using PDT is presented in Table 1.

Table 1

The Distribution of Sentences in each Version of PDT

Sentence type	Number
Filler	42
NP1-biased	7
NP2-biased	7
Unbiased	14

In order to prevent test fatigue, each version was divided into two halves and was presented to the participants in two sessions. Each participant took the first half including 35 items, then after a short break s/he took the second half.

3.2.4. Practice Test

Five sentences were presented to the participants as practice sentences in order to familiarize them with the way the E-Prime software works. The participants were allowed to work with the software for five minutes so that they would know what they should do in the main test. Furthermore, they were free to make any queries regarding the software, procedure, test sentences, etc.

3.3. Procedure

First, the Oxford Quick Placement Test was given to the participants. The time dedicated to answering the test was 60 minutes. Then, the participants took the main test individually on an 18-inch laptop. First, the five-item practice test was administered to familiarize the participants with the task. Afterward, the participants were given the main test consisting of 70 items. The participants received the in a self-paced, noncumulative, chunk-by-chunk fashion in an 18-point Times New Roman font. The participants received each sentence in four segments as indicated by the slashes in sentence (9) above. The participants were instructed that by pressing the space button on the keyboard, a segment would appear on the screen. Each segment remained in the center of the laptop screen until the following key press. After each key press, the segment that the participants had read disappeared; then the new section showed up on the laptop screen. This process proceeded until the last segment of the sentence appeared. Once they had read each item, a True/False statement appeared on the screen. The participants were asked to determine whether the statement was correct or incorrect by pressing "Right arrow" or "Left arrow" buttons on the keyboard, respectively. In high attachment paraphrases, if the 'Right arrow' was chosen, then it was interpreted as a sign of high (NP1) attachment preference, and if the 'Left arrow' was selected, it was considered to be a low (NP2) attachment. In low attachment paraphrases, if the 'right arrow' was chosen, it was recognized as a low (NP2) preference. Finally, if the 'Left arrow' was selected, it was an indication of a high (NP1) attachment preference. No feedback was given regarding their answers. As mentioned earlier, participants took the main test in two sessions; they took 35 items in the first session and the remaining 35 items in the second session. The participants' reading times (RTs) for each segment in each sentence and their answers to true/false statements were recorded by the E-prime software automatically in milliseconds.

Thirty participants provided data on *Version 1* of the Paraphrase Decision Task (PDT), and another thirty participants provided data on *Version 2* of the task. During the course of data collection and analysis the number of participants was reduced to 50 (see results for details).

3.5. Data Analysis

For analyzing the data, descriptive statistics of the measures were calculated and a one-way repeated measures ANOVA was conducted to determine the effects of semantic priming in the three mentioned conditions (i.e., Unbiased, DP1-biased, and DP2-biased). Finally, having categorized the participants into two groups of high-proficiency and low-proficiency;

Repeated measures ANOVA were used to compare reading times for RCs and spillover effect in each group.

4. Results and Discussion

4.1. Results

The main purpose of this study was to see whether the semantic relationship between the RC of the main clause and either of NPs in the complex NP, has any effect on RC attachment preferences of Persian L2 learners of English in ambiguous sentences across different proficiency levels.

The NP chosen by the participants in the Unbiased condition reveals their attachment preferences in general. If they select NP1 as the host of the following RC, it shows that they have a high attachment preference and if they choose NP2 as the host of the following RC, it reveals that they have a low attachment preference. If the semantic relationships have any effect, their attachment preference may change and they will select the NP which is semantically biased toward the RC. It means that when there is a semantic relationship between the RC and NP1, they may choose NP1 as the host of the following RC and when there is a semantic relationship between the RC and NP2, the participants may choose NP2 as the host of the following RC. Moreover, if they choose NP1 as the host of the following RC in all three conditions (Unbiased, NP1-biased, and NP2-biased), it can be concluded that semantics does not affect their preferences, and they transfer their L1 strategies (i.e., high attachment preference) to the processing of L2 ambiguous sentences and if they choose NP2 as the host of the following RC in these three conditions, it can be concluded that they process this type of ambiguous sentences similarly to the native speakers of English strategies (i.e., low attachment preference). Finally, if they choose NP1 in about half of the cases and NP2s in the other half, it can be concluded that they have no attachment preference. This will indicate that semantics is not affecting their performance. But if semantics plays a role, we expect the preferences to vary as a function of biasedness.

4.1.1. Results for Fillers

The participant's answers to fillers were analyzed to select those participants who had paid careful attention to the test. The criterion set for selection was that the participants had to correctly answer at least 90 percent of the fillers. In this way, four participants who did not meet the criterion were omitted from the analyses. On average, the participants answered 96.47% of fillers correctly.

4.1.2. Results for the Proficiency Test

Before analyzing the data from test sentences, data from the proficiency test were analyzed to divide participants into different proficiency levels. The descriptive statistics of results for the proficiency test are presented in Table 2 below.

Table 2

Descriptive Statistics for the Proficiency Test

	N	Minimum	Maximum	Mean	SD
Proficiency	56	29	56	40.75	8.06

The participants were divided into two levels: those with scores lower than the mean and those with scores higher than the mean. Those participants scored nearly one-half standard deviation below or above the mean (i.e., scores between 37 and 43) were excluded in order to clearly separate the two levels. In this way, 28 participants were identified as low-proficient and 22 as high-proficient. The descriptive statistics for two levels are provided in Table 3.

Table 3

Descriptive Statistics for Proficiency Scores for High and Low-level Proficiency

Proficiency	N	Mean	SD
Low	28	33.86	2.91
High	22	49.50	3.86

An independent-samples t-test was conducted and the results showed that the two levels were significantly different from each other (t_{48} = -16.32, p = .000).

4.1.3. Results for the Role of Semantic Priming on Participants' Attachment Preferences (Off-line Data)

In order to find out whether semantics affects participants' attachment preferences, the percentages of their NP1 and NP2 choices across the three conditions were calculated. In the following, results for each group are presented.

4.1.3.1. Low-proficiency Participants

In the Unbiased condition, 70.15% of the participants' responses referred to NP1, while only 29.85% of the responses referred to NP2, which clearly shows that they have a high attachment preference. Similarly, in the NP1-biased condition, 89.28% of responses referred to NP1, but just 10.72% of the participants' responses referred to NP2. Contrary to these two

conditions, in the NP2-biased condition, only 12.25% of the responses referred to NP1 and 87.75% of responses referred to NP2. Participants' answers to sentences in the Unbiased condition reveals their parsing preferences. These results indicate that low-proficiency participants had NP1 attachment preferences. Moreover, the results clearly indicate that semantics affects participants' attachment preferences which means that in NP1-biased condition they have selected the first NP as the host of the RC; and in NP2-biased condition they have selected the second NP as the host of the ambiguous RC. Descriptive statistics are provided in Table 4.

Table 4

Percentage of NP1 and NP2 Selection in the Three Conditions in Low-proficiency Participants

Condition	Antecedent		SD
	NP1	NP2	
Unbiased	70.15%	29.85%	24.05
NP1-biased	89.28%	10.72%	12.06
NP2-biased	12.25%	87.75%	14.39

4.1.3.2. High-proficiency Level Participants

In the Unbiased condition, 62.01% of the responses referred to NP1 while 37.98% of the responses referred to NP2 which shows that they have a high attachment preference. Similarly, in the NP1-biased condition, 85.71% of responses referred to NP1, but just 14.28% of the responses referred to NP2. Contrary to these two conditions, in the NP2-biased condition, only 8.44% of the responses referred to NP1 and 91.55% of responses referred to NP2. These results indicate that high-proficiency participants had an NP2 attachment preference in general. Moreover, the results clearly suggest that semantic priming between the RC and either of NPs affected participants' attachment preferences which means that in NP1-biased condition, they chose the first NP as the host of the RC and in NP2-biased condition, they chose the second NP as the host of the ambiguous RC. Descriptive statistics are provided in Table 5 below.

Table 5

Percentage of NP1 and NP2 Selection in the Three Conditions in High-proficiency Participants

Condition	Antecedent		SD
	NP1	NP2	
Unbiased	37.98%	62.01%	23.47
NP1-biased	85.71%	14.28%	13.94
NP2-biased	8.44%	91.55%	12.20

4.1.4. Results for Time Data (On-line data)

This is very crucial when the processing time of ambiguous sentences is examined. Firstly, it enables the researchers to compare participants' RTs for ambiguous sentences like 5, 6 and 7 in the three different conditions (i.e., Unbiased, NP1-biased, & NP2-biased) which reveals participants' initial parsing preferences. Secondly, it is possible to compare participants' RTs for ambiguous sentences in these three conditions to determine whether the ambiguity resolution has any processing cost for them. For each types of syntactic ambiguity, there is only one preferable interpretation that is always chosen initially by the parser. If the initial interpretation does not agree with the following context, the parser comes back and reanalyze the sentence, which leads to a slow-down in reading. If the parser is not forced to reanalyze the initial interpretation then the ambiguity has no special processing cost since the rise in processing cost happens only when the ambiguous RC is attached to a non-preferred attachment site. Therefore, in the next step, low-proficiency participants' RTs for reading critical region (i.e., region 3) and post-critical region (i.e., region 4) in the three conditions were compared.

Before analyzing the data, participants' RTs for each region were divided by the number of syllables in that region. For example, when the number of syllables for a critical region were five, the participant's RT for that region was divided by five and when the number of syllables were eight, the participant's RT for that region was divided by eight. This was done in order to normalize the RCs and the following regions for their differences in length.

A one-way repeated measures ANOVA was conducted; the three conditions (i.e., Unbiased, NP1-biased, & NP2-biased) were the within-subjects variables and the proficiency level (i.e., high-proficiency & low-proficiency) was the between-subjects factor. Mauchly's test was applied prior to repeated measures tests to check the assumption of sphericity. The results indicated that the assumption of sphericity had been violated, $\chi 2(2) = 95.68$, $p = 0.000$. A one-way repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean RTs for the ambiguous RCs differed statistically significantly between three conditions ($F(1.07, 51.35) = 13.28$, $p = .000$, $\eta p2 = .22$). There was no significant main effect for proficiency, but the results indicated that there was a significant interaction between condition and proficiency level ($F(1.07, 51.35) = 11.465$, $p = .001$, $\eta p2 = .193$). Table 6 presents descriptive statistics for participants' RTs.

Table 6

Descriptive Statistics for Participants' Mean RTs for the RC in the Three Conditions

Condition	Proficiency level	Mean	Std. Deviation	N
Unbiased	Low	486.35	62.06	28
	High	442.14	49.49	22
NP1-biased	Low	497.08	274.06	28
	High	785.78	383.28	22
NP2-biased	Low	938.56	273.56	28
	High	631.43	347.53	22

The results of RTs for RC attachment and spillover effect in high-proficiency and low-proficiency participants are presented below.

4.1.4.1. Results for RTs in RC Processing in Low-proficiency Participants

Mauchly's Test indicated that the assumption of sphericity had been violated, $\chi^2(2) = 56.36$, $p = 0.000$. A one-way repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean RTs for the ambiguous RCs (i.e., *region 3)* differed statistically significantly between three conditions (i.e., Unbiased, NP1-biased, and NP2-biased) ($F(1.06, 28.64) = 26.32$, $p = .000$, $\eta_p^2 = .494$). Post-hoc tests using the Bonferroni correction revealed that there was a significant difference between RTs in three conditions. The results are presented in Table 7 below.

Table 7

Post-hoc Comparisons Between the three Conditions for Participants' Mean RTs for the RC in Low-proficiency Group

(I) condition	(J) condition	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Unbiased	NP1-biased	-10.737	48.793	.000	-135.279	113.805
	NP2-biased	-452.219*	54.678	000	-591.782	-312.655
NP1-biased	Unbiased	10.737	48.793	.000	-113.805	135.279
	NP2-biased	-441.481*	99.031	000	-694.253	-188.709
NP2-biased	Unbiased	452.219*	54.678	000	312.655	591.782
	NP1-biased	441.481*	99.031	000	188.709	694.253

The participants produced shorter RTs for sentences in Unbiased (*M*= 486.35, *SD*= 62.06) and NP1-biased (*M*= 497.08, *SD*= 274.06), but very longer RTs to sentences in which the RC was semantically associated with NP2 (*M*= 938.56, *SD*= 273.56). Moreover, there was also a slight but not significant difference between the Unbiased condition and NP1-biased condition in which RC was biased towards NP1. Participants had a high attachment preference, so the RTs for reading Unbiased and NP1-biased sentences were significantly shorter than the Unbiased condition meaning that the participants had difficulty while processing NP2-biased ambiguous sentences and these sentences have higher processing cost for low-proficiency participants. Descriptive statistics are presented in Table 8 below.

Table 8

Low-proficiency Participants' Mean RTs for the RC in the Three Conditions

	Mean	Std. Deviation	N
Unbiased	486.35	62.06	28
NP1-biased	497.08	274.06	28
NP2-biased	938.56	273.56	28

4.1.4.2. Results of RTs for Spillover Effect in Low-proficiency Participants

Next, the spillover effect was examined among the three conditions because the parser may transfer the processing cost to the next section (i.e., the post-critical region) while processing the ambiguous RC. Mauchly's test was used to check whether the assumption of sphericity was met. The results showed that, it had also been violated in case of spillover effect, $\chi 2(2) = 9.84$, $p = .007$. Again, a repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean RTs for the post-critical region (i.e., region 4) differed statistically significantly between the three mentioned conditions $F(1.52, 41.06) = 15.59$, $p = .000$, $\eta p2 = .366$) meaning that the processing cost was transferred to the next adjacent region which means that they had difficulty in processing the critical region even when they were reading the unambiguous region. Post-hoc tests using Bonferroni correction showed that there were significant differences between the RTs in the three conditions. The results are presented in Table 9 below.

Similar to processing of the RCs, low-proficiency participants produced shorter reading times for sentences in the Unbiased (M= 827.44, SD= 81.43) and NP1-biased (M= 850.35, SD= 153.70) conditions, but longer reading times to sentences in which the RC was semantically associated with NP2 (M= 1044.11, SD= 261.35). Additionally, there was no significant difference between RTs in the Unbiased condition and the NP1-biased condition. Descriptive statistics are presented in Table 10 below.

Table 9

Post-hoc Comparisons Between the three Conditions for Participants' Mean RTs for the Spillover Effect in Low-proficiency Group

(I) condition	(J) condition	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Unbiased	NP1-biased	-22.912	29.080	1.000	-97.138	51.315
	NP2-biased	-216.668*	45.111	.000	-331.813	-101.524
NP1-biased	Unbiased	22.912	29.080	1.000	-51.315	97.138
	NP2-biased	-193.757*	50.720	.002	-323.217	-64.296
NP2-biased	Unbiased	216.668*	45.111	.000	101.524	331.813
	NP1-biased	193.757*	50.720	.002	64.296	323.217

Table 10

Mean RTs for the Spillover Effect in the Three Conditions in Low-proficiency Group

	Mean	Std. Deviation	N
Unbiased	827.44	81.43	28
NP1-biased	850.35	153.70	28
NP2-biased	1044.1 1	261.35	28

4.1.4.3. Results for RTs in RC Processing of High-proficiency Participants

Assumption of Sphericity was violated in Mauchly's test, $\chi^2(2) = 41.49$, $p = 0.000$. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean RTs for the ambiguous RCs (i.e., *region 3)* differed statistically significantly among three conditions (i.e., Unbiased, NP1-biased, and NP2-biased) ($F(1.06, 22.40) = 5.09$, $p = .032$, $\eta_p^2 = .195$). Post-hoc tests using Bonferroni correction revealed that there were significant differences between RTs in three conditions. Table 11 presents the results.

The participants produced shorter RTs for sentences in the Unbiased condition ($M = 442.14$, $SD = 49.49$), but longer RTs to sentences in which the RC was semantically associated with NP1-biased ($M = 785.78$, $SD = 383.28$) and NP2 ($M = 631.43$, $SD = 347.53$). Moreover, the RTs for NP2-biased condition were shorter but not significantly different compared to NP1-biased. High-proficiency participants had a low attachment preference; the RTs for reading Unbiased and NP2-biased sentences were shorter than the NP1-biased condition meaning that the participants had difficulty while

processing NP1-biased ambiguous sentences and these sentences have higher processing costs for high-proficiency participants. Descriptive statistics are presented in Table 12.

Table 11

Post-hoc Comparisons Between the three Conditions for Participants' Mean RTs for the RC in High-proficiency Group

(I) condition	(J) condition	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Unbiased	NP1-Biased	-343.637*	86.859	.002	-569.587	-117.686
	NP2-Biased	-189.289*	70.322	.041	-372.221	-6.356
NP1-Biased	Unbiased	343.637*	86.859	.002	117.686	569.587
	NP2-Biased	154.348	149.67	.942	-235.004	543.700
NP2-Biased	Unbiased	189.289*	70.322	.041	6.356	372.221
	NP1-Biased	-154.348	149.67	.942	-543.700	235.004

Table 12

High-proficiency Participants' Mean RTs for the RC in the Three Conditions

	Mean	Std. Deviation	N
Unbiased	442.35	49.49	22
NP1-biased	785.08	383.28	22
NP2-biased	631.56	347.53	22

4.1.4.4. Results of RTs for Spillover Effect in High-proficiency Participants

Finally, the spillover effect was examined among the three conditions for high-proficiency participants. Mauchly's Test of Sphericity showed that the assumption of sphericity had also been violated in case of spillover effect, $\chi^2(2) = 8.18$, $p = .017$. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean RTs for the post-critical region (i.e., *region 4)* were not statistically significantly different across the three mentioned conditions $F(1.49, 31.44) = 3.03$, $p = .07$, $\eta_p^2 = .366$) meaning that there were no spillover effects while processing these types of sentences for high-proficiency participants. Results are presented in Table 13.

Table 13

Post-hoc Comparisons Between the three Conditions for Participants' Mean RTs for the Spillover Effect in Low-proficiency Group

(I) condition	(J) condition	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
Unbiased	NP1-biased	-104.230	46.130	.104	-224.231	15.770
	NP2-biased	-34.145	28.694	.742	-108.788	40.499
NP1-biased	Unbiased	104.230	46.130	.104	-15.770	224.231
	NP2-biased	70.085	51.332	.560	-63.446	203.617
NP2-biased	Unbiased	34.145	28.694	.742	-40.499	108.788
	NP1-biased	-70.085	51.332	.560	-203.617	63.446

Descriptive statistics are presented in Table 14 below.

Table 14

Mean RTs for the Spillover Effect in the Three Conditions in Low-proficiency Group

	Mean	Std. Deviation	N
Unbiased	764.86	86.37	22
NP1-biased	869.09	216.37	22
NP2-biased	799.01	180.87	22

4.2. Discussion

As discussed above, the NP chosen by the participants in the Unbiased condition reveals their attachment preferences in general. Low-proficiency level participants preferred NP1 as the host of the following RC in the Unbiased condition indicating that they had a high attachment preference. Moreover, when there was a semantic relationship between the RC and NP1 they have selected NP1 as the host of the following RC, and when there was a semantic relationship between the RC and NP2, low-proficiency participants have selected NP2, as the host of the following RC which shows that semantics have affected their attachment preferences. Contrary to low-proficiency participants, in the high-proficiency level, participants preferred NP2 as the host of the ambiguous RC in the Unbiased condition. Similar to low-proficiency participants, high-proficiency participants have chosen NP1 as the host of the ambiguous RC in NP1-biased condition and have chosen NP2 as the host of the ambiguous RC in NP2-biased condition.

Putting together these two findings, it can be concluded that both semantic priming and the proficiency level of participants play a crucial role in their attachment preferences.

Low-proficiency participants process the ambiguous sentences similarly to the way they do in their mother tongue. Cross-linguistic differences and the low level of proficiency of these learners may have resulted in the transfer of their processing strategies from their first language (Persian) to their second language (English), following the principles of Predicate Proximity they attached the ambiguous RC to NP1. These findings are in line with previous studies that reported L1 transfer in L2 sentence processing (Dussias, 2003; Frenck-Mestre, 2002).

High-proficiency participants employed L2 processing strategies (Late Closure Principle). But the rate of NP2 selection obtained from highly-proficient Persian L2 learners of English was not exactly similar to that of English native speakers. They did not employ their L1 processing strategies (Predicate Proximity principles) because, unlike what they do in their mother tongue, they did not attach the ambiguous RC to NP1. They have chosen NP1 as the host of the ambiguous RC in only 37.98% of sentences while they have chosen NP2 in 62.02% of sentences which shows that high-proficiency participants have not processed sentences similarly to English native speakers because their comprehension representations are not as elaborate as those of English native speakers and as a result they have a less automatic and less target-like processing behaviors compared to English native speakers. These findings are consistent with the predictions of Shallow Structure Hypothesis (Clahsen & Felser, 2006). The results support the notion that even highly proficient L2 learners do not attain a native level proficiency in the second language (Jiang, 2007).

Considering the role of semantics both low-proficiency and high-proficiency participants chose NP1 as the host of the RC in NP1-biased condition and in NP2-biased condition they have selected NP2 as the host of the RC. The findings are consistent with Constraint-based Models (Green & Mitchell, 2006; MacDonald 1994; Thornton et al., 1998; Traxler et al., 2000) which assume during sentence processing, several sources of information including semantic plausibility, and discourse context interaction are used by the parser during the processing of ambiguous sentences. Therefore, in addition to the phrase-structure information, discourse and lexical information including semantic information exert an influence on participants' processing. The findings are also in line with the Spreading Activation Model's predictions (Collins & Loftus, 1975; Dell, 1986; Traxler et al., 2000) which posit that when a word is activated, other semantically related words also become activated, these words (the NPs and the biased RCs) reinforce the activation of each other and make the NP to which the RC is biased towards more accessible, and make the parser attach the RC to it.

Despite the fact that the general picture is clear, it would be interesting to see that the attachment preferences of high and low-proficiency participants in the three different aforementioned conditions were different in the RTs measures. One the one hand, for low-proficiency participants, processing cost for critical regions in the NP2-biased condition was enhanced because participants' initial attachment (i.e., NP1) had to be revised since the RC was semantically biased towards a non-preferred attachment (i.e., NP2) so, they had to refixate their initial NP1 attachment as the host of the following RC which led to longer RTs. In the Unbiased and NP1-biased conditions, low-proficiency participants, based on Predicate Proximity principle, attached the ambiguous RCs to the first NP. Since no reanalysis was necessary, they did not recheck NP1 attachment for RCs as it was the preferred one, so they produced shorter RTs. On the other hand, for high-proficiency participants, processing cost for the critical region in the NP1-biased condition was enhanced. This happened because participants' initial attachment (NP2) had to be revised since the RC was semantically biased towards a non-preferred attachment site (NP1). Therefore, they had to refixate their initial NP1 attachment as the host of the following RC which led to longer RTs. In the Unbiased and NP2-biased conditions, the high-proficiency participants, based on Late Closure principle, attached the ambiguous RCs to the second NP and since no reanalysis was necessary, they did not recheck NP2 attachment for RCs as it was the preferred one, so they produced shorter RTs in these two conditions.

5. Conclusion and Implications

The purpose of this study was to see whether or not the semantic relationship between the RC and either of the NPs in a complex NP, has any effect on RC attachment preferences of L1-Persian L2 leaners of English.

On the whole, the results of RC attachment preferences of Persian L2 learners of English in NP1-biased, NP2-biased and Unbiased conditions showed that semantic manipulation clearly affects participants' attachment preferences. The participants followed Constraint-based theories of sentence processing which assume that initial decisions rely on multiple sources of information. In addition to syntactic information, other sources of information including semantics are used during parsing ambiguous sentences.

Theoretical and pedagogical implications could be derived from the results of the study. The results provide strong support for Constraint-based Models of parsing and also Shallow Structure Hypothesis. The findings also indicate that there is an inverse relationship between proficiency and L1 transfer which means that as alongside improvements in proficiency level, the rate of L1 transfer decreases. Low proficiency participants transferred

their L1 parsing preferences to their L2 while high-proficiency participants process ambiguous sentences similarly to English native speakers. Thus, any attempt to boost learners' proficiency will make their processing more and more similar to that of native speakers which was the case for high-proficiency participants. Additionally, based on contrastive analysis hypothesis, in some cases the teacher has to point out the differences between learners' L1 and L2, for which RC attachment ambiguity is a good example. Moreover, teachers themselves can benefit from ambiguous RCs, as they are required to have enough knowledge of these structures so that they can explain them to the learners.

Future research can build on results of the present study and explore various aspects of it. In this study the role of semantics and proficiency were investigated. Future research can affect the role of WMC in participants' parsing preferences. The role of WMC in ambiguity resolution is still open to debate in the literature and clear-cut answers as to how low and high span readers process ambiguous RCs has not yet been reached (e.g., Fedorenko et al., 2006; Hopp, 2014; Traxler, 2007). The interactive effects of semantics and WMC is also another relevant area which can be taken up by future research.

Moreover, in this study, Persian L2 learners with different levels of proficiency were tested. One important issue that deserves more investigation is the issue of the context of the study. It would be more revealing if the study is replicated with English native speakers to directly compare their data with those from participants in this study to see whether semantics affects their parsing preferences.

Furthermore, the study can be replicated with a more representative sample. All participants taking part in the present study had learned English as a foreign language. This issue is worth paying more attention to since it seems that there is less L1 parsing interference in the case of people using L2 as their second language (Dussias & Sagarra, 2007).

Further methodological work is also needed on the type of ambiguous sentences used in RC processing studies. In this study, the ambiguous sentences were of the object-modifying RC type. It would also be helpful to draw a comparison between the object-modifying and subject-modifying RCs to find out whether the participants have a consistent RC attachment on occasions when the type of RC ambiguous sentence changes.

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Appendices

Experimental sentences

Test sentences

Set 1

1. Alex saw the patient of the nurse who was seriously injured last week.
2. Alex saw the patient of the nurse who was filling the syringe last week.
3. Alex saw the patient of the nurse who was speaking to the doctor last week.

Set 2

1. David met the teacher of the student who was teaching mathematic last night.
2. David met the teacher of the student who was playing in yard last night.
3. David met the teacher of the student who was eating dinner last night.

Set 3

1. Henry admired the bodyguard of the president who was shooting the suspects two days ago.
2. Henry admired the bodyguard of the president who was giving a speech in UN two days ago.
3. Henry admired the bodyguard of the president who was wearing black shoes two days ago.

Set 4

1. Adam called the hairdresser of the actress who was doing a haircut on Monday morning.
2. Adam called the hairdresser of the actress who was practicing the script on Monday morning.
3. Adam called the hairdresser of the actress who was eating breakfast on Monday morning.

Set 5

1. Edward employed the driver of the manager who was parking the car this morning.
2. Edward employed the driver of the manager who was signing the contract this morning.
3. Edward employed the driver of the manager who was eating breakfast this morning.

Set 6

1. Tommy invited the secretary of the doctor who was arranging the meetings last night.
2. Tommy invited the secretary of the doctor who was prescribing medicine last night.
3. Tommy invited the secretary of the doctor who was wearing brown shoes last night.

Set 7

1. Max recognized the photographer of the singer who was taking photos last night.
2. Max recognized the photographer of the singer who singing a new song last night.
3. Max recognized the photographer of the singer who was trying to sleep last night.

Set 8

1. Joey met the lawyer of the criminal who was working for the law firm in 1990's.
2. Joey met the lawyer of the criminal who was serving his prison sentence in 1990's.
3. Joey met the lawyer of the criminal who was living in New York in 1990's.

Set 9

4. Maria encouraged the accountant of the manager who was examining financial records three years ago.
5. Maria encouraged the accountant of the manager who was running the organization three years ago.
6. Maria encouraged the accountant of the manager who was wearing glasses three years ago.

Set 10

1. Jennifer invited the surgeon of the player who was doing a surgery on Wednesday morning.
2. Jennifer invited the surgeon of the player who was playing football on Wednesday morning.
3. Jennifer invited the surgeon of the player who was who was sleeping on Wednesday morning.

Set 11

1. Emma liked the waitress of the actor who was cleaning the table in the afternoon.
2. Emma liked the waitress of the actor who was playing in movie in the afternoon.
3. Emma liked the waitress of the actor who was drinking coffee in the afternoon.

Set 12

1. Emily admired the dentist of the child who was removing tooth decay this morning.
2. Emily admired the dentist of the child who was suffering from tooth pain this morning.
3. Emily admired the dentist of the child who was standing in the hall this morning.

Set 13

1. Eva talked with the physiotherapist of the boxer who was working in a hospital last week.
2. Eva talked with physiotherapist of the boxer who was practicing for championship last week.
3. Eva talked with the physiotherapist of the boxer who was walking in the street last week.

Set 14

1. Jasmine adored the pilot of the judge who was working for the British airline three years ago.
2. Jasmine adored the pilot of the judge was working for law firm three years ago.
3. Jasmine adored the pilot of the judge who was living in a big city three years ago.

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